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Applicant(s): Kenji IKOMA

Application No.: **NEW APPLICATION**

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For: VIBRATION DAMPING APPARATUS FOR RECICPROCATING DRIVE AND CUTTING HEAD (as amended)

LETTER

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Sir:

Amended sheets are attached hereto (which correspond to Article 34 amendments), as required by 35 U.S.C. § 371(c)(3). The Article 34 amended sheets are incorporated in the included Preliminary Amendment.

Respectfully submitted,

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motion is caused by the crank mechanism as in JP-B-6-53358, a cutting head that protrudes a cutting blade downward requires a space for a link mechanism in the above thereof thus resulting in an increased height of the cutting head. Meanwhile, because the cranks are opposed at 180 degrees, in case the link mechanism is coupled to one lateral direction of a crank axis, a couple of forces occur at axial front and rear of the crank.

Disclosure of Invention

It is an object of the present invention to provide a vibration damping apparatus for reciprocating drive and cutting head capable of damping the vibration resulting from a reciprocal motion by attaining a balance by means of a simple structure, which can be easily reduced in size.

The invention is a vibration damping apparatus for reciprocating drive, for damping vibration occurring upon conversion of rotary motion which is obtained on a rotation outputting shaft of a rotation drive source into reciprocal motion in a predetermined reciprocating drive direction perpendicular to the rotation outputting shaft, comprising:

a first conversion mechanism having a first rotary shaft parallel with the rotation outputting axis to which rotary motion from the rotation drive source is transmitted, for converting a rotary motion of the first rotary shaft so that a reciprocal motion in the predetermined reciprocating drive direction

perpendicular to the first rotary shaft is included in a drive position provided eccentrically from the first rotary shaft;

a second conversion mechanism provided in pair with the first conversion mechanism so as not to be in contact with the first conversion mechanism and arranged symmetric with the first conversion mechanism with respect to a reference virtual plane parallel with the predetermined reciprocating drive direction, for converting a rotary motion of a secondary rotary shaft which rotates at equal speed reverse to and is parallel with the first rotating shaft so that a reciprocal motion in the reciprocating drive direction is included in a drive position provided eccentrically from the second rotary shaft, synchronously with a reciprocal motion converted by the first conversion mechanism;

a combining mechanism for extracting and combining together reciprocal motions in the reciprocating drive direction which is converted from rotary motions by the first conversion mechanism and the second conversion mechanism, respectively;

a first counter weight having a center of gravity in a position on a side symmetric with the drive position with respect to the first rotary shaft, for taking a balance with an offset load occurring upon motion conversion; and

a second counter weight provided in pair with the first counter weight and having a center of gravity in a position on a side symmetric with the drive position with respect to

the second rotary shaft, for taking a balance with an offset load occurring upon motion conversion,

wherein rotary driving force from the rotation drive source is transmitted via a belt to the first conversion mechanism and the second conversion mechanism.

Furthermore, the invention is characterized by further comprising a third counter weight provided on a third rotary shaft parallel with the first rotary shaft and rotating reverse at a rotational speed twice a rotational speed of the first rotary shaft, the third counter weight being lighter in weight than the first counter weight and eccentric in center-of-gravity position with respect to the third rotary shaft; and

a fourth counter weight provided in pair with the third counter weight and arranged symmetric with the third counter weight with respect to the reference virtual plane, the fourth counter weight being provided on a fourth rotary shaft parallel with the second rotary shaft and rotating reverse at a rotational speed twice a rotational speed of the second rotational shaft, the fourth counter weight being lighter in weight than the second counter weight and eccentric in center-of-gravity position with respect to the fourth rotary shaft.

Furthermore, the invention is characterized in that the combining mechanism carries out the combining so that the drive direction is on the reference virtual plane.

Furthermore, the invention is characterized in that the

first conversion mechanism and the second conversion mechanism are crank mechanisms each provided with a crank rod, respectively, having one end pivotably and displaceably coupled to the drive position;

the combining mechanism including

coupling members pivotably and displaceably coupled to other ends of crank rods of the first conversion mechanism and second conversion mechanism, respectively, and

a guide mechanism for guiding a reciprocal motion combined by the coupling member, in the drive direction.

Furthermore, the invention is characterized in that center-of-gravity positions of the first and second counter weights and the drive direction are on a virtual plane perpendicular to the reference virtual plane.

The invention is a vibration damping apparatus for reciprocating drive, for damping vibration occurring upon conversion of rotary motion into reciprocal motion, comprising:

a first conversion mechanism for converting a rotary motion of a first rotary shaft so that a reciprocal motion in a predetermined drive direction perpendicular to the first rotary shaft is included in a drive position provided eccentrically from the first rotary shaft;

a second conversion mechanism provided in pair with the first conversion mechanism and arranged symmetric with the first conversion mechanism with respect to a reference virtual plane

parallel with the predetermined drive direction, for converting a rotary motion of a secondary rotary shaft which rotates at equal speed reverse to and is parallel with the first rotating shaft so that a reciprocal motion in the drive direction is included in a drive position provided eccentrically from the second rotary shaft, synchronously with a reciprocal motion converted by the first conversion mechanism;

a combining mechanism for extracting and combining together reciprocal motions in the drive direction converted from rotary motions by the first conversion mechanism and the second conversion mechanism, respectively;

a first counter weight having a center of gravity in a position on a side symmetric with the drive position with respect to the first rotary shaft, for taking a balance with an offset load occurring upon motion conversion; and

a second counter weight provided in pair with the first counter weight and having a center of gravity in a position on a side symmetric with the drive position with respect to the second rotary shaft, for taking a balance with an offset load occurring upon motion conversion,

the vibration damping apparatus for reciprocating drive further comprising:

a rotation drive source for deriving a rotation output from a driving pulley;

a first driven pulley provided on the first rotary shaft;

a second driven pulley provided on the second rotary shaft so as to be paired with the first driven pulley;

an idle pulley provided so as to freely rotate; and

a belt stretched over the driving pulley, the first driven pulley, the second driven pulley and the idle pulley, for conveying a rotation drive force from the driving pulley to the first driven pulley and the second driven pulley so that rotational directions of the rotation drive force become different between the first driven pulley and the second driven pulley.

Furthermore, the invention is a cutting head comprising a vibration damping apparatus for reciprocating drive according to any one of the above ones, the cutting head reciprocally driving a cutting blade on a reciprocal motion combined by the combining mechanism.

CLAIMS

1. A vibration damping apparatus for reciprocating drive, for damping vibration occurring upon conversion of rotary motion which is obtained on a rotation outputting shaft of a rotation drive source into reciprocal motion in a predetermined reciprocating drive direction perpendicular to the rotation outputting shaft, comprising:

a first conversion mechanism having a first rotary shaft parallel with the rotation outputting axis to which rotary motion from the rotation drive source is transmitted, for converting a rotary motion of the first rotary shaft so that a reciprocal motion in the predetermined reciprocating drive direction perpendicular to the first rotary shaft is included in a drive position provided eccentrically from the first rotary shaft;

a second conversion mechanism provided in pair with the first conversion mechanism so as not to be in contact with the first conversion mechanism and arranged symmetric with the first conversion mechanism with respect to a reference virtual plane parallel with the predetermined reciprocating drive direction, for converting a rotary motion of a secondary rotary shaft which rotates at equal speed reverse to and is parallel with the first rotating shaft so that a reciprocal motion in the reciprocating drive direction is included in a drive position provided eccentrically from the second rotary shaft, synchronously with a reciprocal motion converted by the first conversion mechanism;

a combining mechanism for extracting and combining together reciprocal motions in the reciprocating drive direction which is converted from rotary motions by the first conversion mechanism and the second conversion mechanism, respectively;

a first counter weight having a center of gravity in a position on a side symmetric with the drive position with respect to the first rotary shaft, for taking a balance with an offset load occurring upon motion conversion; and

a second counter weight provided in pair with the first counter weight and having a center of gravity in a position on a side symmetric with the drive position with respect to the second rotary shaft, for taking a balance with an offset load occurring upon motion conversion,

wherein rotary driving force from the rotation drive source is transmitted via a belt to the first conversion mechanism and the second conversion mechanism.

2. The vibration damping apparatus for reciprocating drive of claim 1, further comprising:

a third counter weight provided on a third rotary shaft parallel with the first rotary shaft and rotating reverse at a rotational speed twice a rotational speed of the first rotary shaft, the third counter weight being lighter in weight than the first counter weight and eccentric in center-of-gravity

position with respect to the third rotary shaft; and

a fourth counter weight provided in pair with the third counter weight and arranged symmetric with the third counter weight with respect to the reference virtual plane, the fourth counter weight being provided on a fourth rotary shaft parallel with the second rotary shaft and rotating reverse at a rotational speed twice a rotational speed of the second rotational shaft, the fourth counter weight being lighter in weight than the second counter weight and eccentric in center-of-gravity position with respect to the fourth rotary shaft.

3. The vibration damping apparatus for reciprocating drive of claim 1 or 2, wherein the combining mechanism carries out the combining so that the drive direction is on the reference virtual plane.

4. The vibration damping apparatus for reciprocating drive of any one of claims 1 to 3, wherein the first conversion mechanism and the second conversion mechanism are crank mechanisms each provided with a crank rod, respectively, having one end pivotably and displaceably coupled to the drive position;

the combining mechanism including

coupling members pivotably and displaceably coupled to other ends of crank rods of the first conversion mechanism and second conversion mechanism, respectively, and

a guide mechanism for guiding a reciprocal motion combined by the coupling member, in the drive direction.

5. The vibration damping apparatus for reciprocating drive of claim 4, wherein center-of-gravity positions of the first and second counter weights and the drive direction are on a virtual plane perpendicular to the reference virtual plane.

6. A vibration damping apparatus for reciprocating drive, for damping vibration occurring upon conversion of rotary motion into reciprocal motion, comprising:

a first conversion mechanism for converting a rotary motion of a first rotary shaft so that a reciprocal motion in a predetermined drive direction perpendicular to the first rotary shaft is included in a drive position provided eccentrically from the first rotary shaft;

a second conversion mechanism provided in pair with the first conversion mechanism and arranged symmetric with the first conversion mechanism with respect to a reference virtual plane parallel with the predetermined drive direction, for converting a rotary motion of a secondary rotary shaft which rotates at equal speed reverse to and is parallel with the first rotating shaft so that a reciprocal motion in the drive direction is included in a drive position provided eccentrically from the second rotary shaft, synchronously with a reciprocal motion

converted by the first conversion mechanism;

a combining mechanism for extracting and combining together reciprocal motions in the drive direction converted from rotary motions by the first conversion mechanism and the second conversion mechanism, respectively;

a first counter weight having a center of gravity in a position on a side symmetric with the drive position with respect to the first rotary shaft, for taking a balance with an offset load occurring upon motion conversion; and

a second counter weight provided in pair with the first counter weight and having a center of gravity in a position on a side symmetric with the drive position with respect to the second rotary shaft, for taking a balance with an offset load occurring upon motion conversion,

the vibration damping apparatus for reciprocating drive further comprising:

a rotation drive source for deriving a rotation output from a driving pulley;

a first driven pulley provided on the first rotary shaft;

a second driven pulley provided on the second rotary shaft so as to be paired with the first driven pulley;

an idle pulley provided so as to freely rotate; and

a belt stretched over the driving pulley, the first driven pulley, the second driven pulley and the idle pulley, for conveying a rotation drive force from the driving pulley to

the first driven pulley and the second driven pulley so that rotational directions of the rotation drive force become different between the first driven pulley and the second driven pulley.

7. A cutting head comprising:

the vibration damping apparatus for reciprocating drive according to any one of claims 1 to 6,

the cutting head reciprocally driving a cutting blade on a reciprocal motion combined by the combining mechanism.